Performance of fishing gear on skipjack tuna *Katsuwonus pelamis* in south Sulawesi, Indonesia

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Abstract. Skipjack tuna is the main target for commercial fisheries in the Luwu District, Bone Bay. The fish catching is performed all year long, so the overharvesting of this species tends to increase. The goal of the study is to analyze the performance skipjack tuna fishing gear (pole and line, hand line, and seine net) based on four aspects: biological, technical, social, and economical. Design the of study is direct observation in the field using interview method to choice respondent as like owner of fishing boat and other people choice each skipjack fishing gear. The analysis used scoring methods. Result of the study indicated that the pole and line was the optimal choice in technical and economical aspect, but hand line the optimal in biological and social aspect. The main priority of fishing gears in succession was first pole and line, second hand line and last seine net. The conclusion was that the fishing gear of pole and line had the best performance than others fishing gear in District Luwu. The fishing gear was also suitable to be continued and developed in the future because its profitable and short time in payback periods.
Key Words: pole and line, hand line, seine net, overharvesting, development, Bone Bay.

Introduction. In Bone Bay (Luwu Regency, South Sulawesi, Indonesia) the fishermen's main target is on skipjack tuna catching. Bone Bay was known already as potential fishing ground for skipjack tuna (Zainuddin et al 2013; Mallawa 2013). Fishing gears used for catching skipjack tuna (*Katsuwonus pelamis*) namely pole and line, hand line and seine net (Marine and Fisheries Service of Luwu Regency 2012).

K. pelamis have high market potential and also high price and contribute to the fishermen's profit. *K. pelamis* is a favorite food and used as a raw material for food industry and also as main culinary menu in the certain regions either in Indonesia or overseas. Due to those reasons, *K. pelamis* become the main target by fishermen in the Bone Bay. They used varies fishing gear namely pole and line, hand line and seine net (Catalogue of Centre Statistic Board 2012).

Development of fishing technology from year to year became more intensive and tends to catch more and smaller specimens. Therefore, the sustainability of tuna fishing in this area is a big question mark and need to be evaluated. In this regard this research is conducted in order to evaluate fishing gears performances based on four management aspects namely: biological, technical, social and economical.

The previous research related to *K. pelamis* in the Bone Bay were: average size of pole and liner length (L) 22.42 m, breadth (B) 3.82 m and height (D) 1.83 m. The main dimension ratio were L/B = 5.66–6.08, L/D = 11.3913.16, and B/D = 1.94–2.26. Whereas standard ratio for pole and liner were L/B = 4.80, L/D = 10.00, B/D = 1.95 (Abdullah 2011). *K. pelamis* catching dominated by small and medium size (26-34 cm) and still young fish 38.36% (Mallawa 2013). Jamal et al (2011) found that proportion of young *K. pelamis* is still high, around 43.9%-54.6% at Bone Bay. This condition will threat *K. pelamis* population due to over exploitation. Data from local government indicated that *K. pelamis* production were significantly decreasing during year 2003 to 2006 from 1,157.9 ton/year become 16.4 ton/year. In the year 2007 *K.*

pelamis production was getting recovered and continuing increase up to 425.6 ton/year in 2011 (Marine and Fisheries Service of South Sulawesi 2012)

Refer to the above facts it is need to regulate *K. pelamis* fishing technology based on fish resources, applied technology and feasibility to develop based on four management aspects (biological, technical, social and economical).

The research aimed to study and evaluate the *K. pelamis* fishing technology that feasible to develop based on four management aspects that could be utilized optimally.

Material and Method. The research was conducted during March through October 2013 in Bone Bay (Luwu Regency, South Sulawesi, Indonesia). Fishing base for pole and liner is located at Murante fish landing site, sub-district of Suli and for hand liner and also purse seiner is located at Balambang fish landing site, sub-district of Bua (Figure 1).

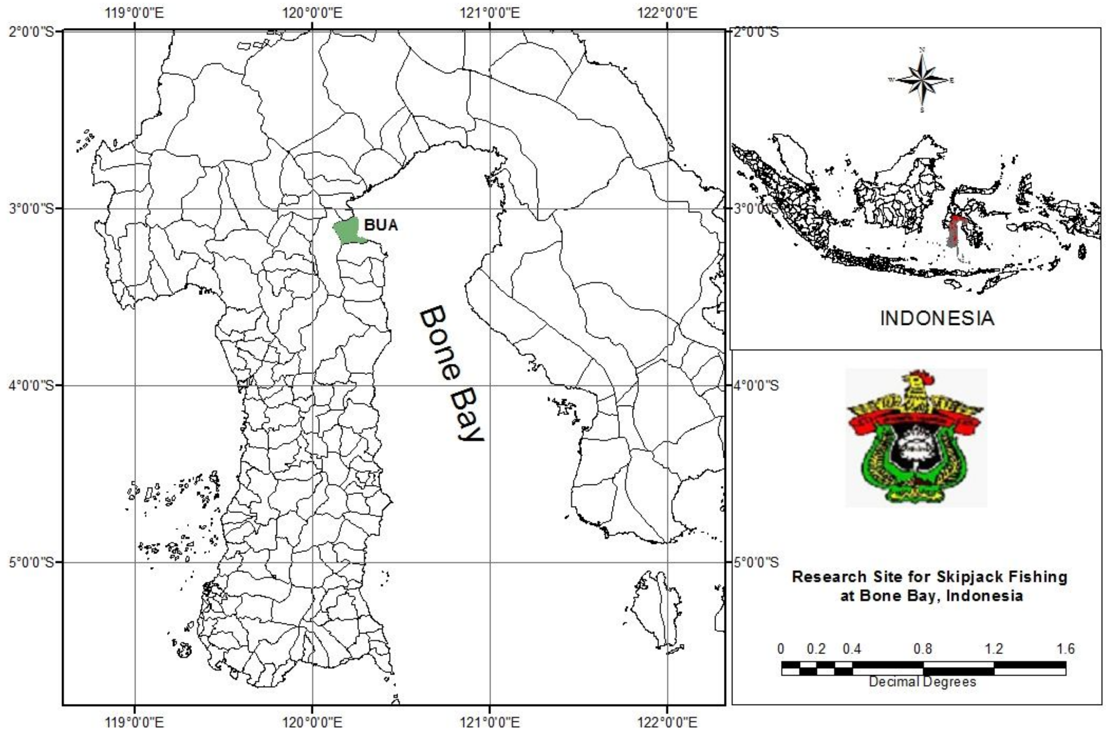

Figure 1. Research site for skipjack tuna fishing at South Sulawesi, Indonesia.

Survey methods were applied for this research with sampling purpose. Samples were selected based on certain consideration that could give well information required. Firstly, the researcher pointed out respondent samples that represent the skipjack fishermen population. The respondents consist of local fishermen group, business owner, and local fisheries service staff. After respondents were selected, interviews were conducted based on structured question list related to management aspects required. Direct observation in the field was performed through participation in the fishing operation of each fishing gear type. Data collected through direct observation were: fishing operation methods, species and number of fish yields, and documentation. Data for economic analysis was: total revenue and total spending per year. Total cost was consisting of investment, fixed cost, and variable cost.

Data analysis used scoring method and continued with value function as proposed by Mangkusubroto & Trisnadi (1985).

$$v(x) = \frac{x - xo}{x1 - xo}$$

$$V(A) = \sum_{i=a}^{n} Vi(Xi)$$

where :

i	= 1, 2, 3, ……. n;
Xo	= the worst value in X criteria;
X1	= the best value in X criteria;
V(A)	= function value for alternative A;
Vi(Xi)	= function value for i alternative at i criteria.

Selection for fishing units used scoring methods as followings criteria: biological aspects were: selectivity (X1), average length of *K. pelamis* catches (X2), duration of *K. pelamis* fishing season (X3), percentage of *K. pelamis* feasible catch size (X4), and implementation of environmental friendly fishing technology (X5). These aspects observed through direct interview to fishermens. The followed technical aspects were: *K. pelamis* production per year (X1), *K. pelamis* production per trip (X2), and *K. pelamis* production per crew (X3). Social aspects: number of crew for fishing unit (X1), technology levels of crew (X2), and respond of local fishermens (X3). Economic aspects: gross revenue per year (X1), gross revenue per trip (X2), gross revenue per crew (X3), benefit (X4), and revenue cost ratio (R/C) (X5).

Results. Assessment on *K. pelamis* fishing gear performance based on biological aspects is shown on Table 1. Table 1 showed that hand line is the first priority in the all biological criterias except X3 length of fishing season. Based on biological aspects the priority for development were hand line, pole and line and seine net respectively.

Table 1

Biological aspects of fishing gear performances

Fishing gears	*Criteria*										*V(A)*	*Priority*
	X1	*V1 (X1)*	*X2*	*V2 (X2)*	*X3*	*V3 (X3)*	*X4*	*V4 (X4)*	*X5*	*V5 (X5)*		
Pole and line	3	0.67	45	0.57	7	1	41	0.43	4	1	3.67	2
Hand line	4	1	60	1	5	0.5	95	1	4	1	4.5	1
Seine net	1	0	25	0	3	0	1	0	1	0	0	3

Where:

X_1 = Fishing gear selectivity with score:

1 = catching >3 fish species with relative uniform size;
2 = catching 3 fish species or less with high variation in size;
3 = catching <3 fish species with relative uniform size;
4 = catching 1 fish species with relative uniform size;

X_2 = Average length size of skipjack fish catch (cm).

X_3 = Length of fishing seasons (months).

X_4 = Percentage of feasible catching size (%).

X_5 = Utilization of environmental fishing technology with score:

1 = fulfill 2 criteria of environmental friendly fishing technology;
2 = fulfill 3-5 criteria of environmental friendly fishing technology;
3 = fulfill 5-7 criteria of environmental friendly fishing technology;
4 = fulfill all criteria of environmental friendly fishing technology;

V (A) = Value function of alternative A;

$V_i (X_i)$ = Value function for alternative i and criteria I;

UP = priority rank.

Technical aspect (Table 2) indicated that superiority assessment for technical aspect pole and line was top priority for all criteria.

Table 2

Technical aspects of fishing gear performances

Fishing gears	*Criteria*						*V(A)*	*Priority*
	X1	*V1(X1)*	*X2*	*V2(X2)*	*X3*	*V3(X3)*		
Pole and Line	300000	1	800	1	70	0.5	2.5	1
Hand Line	120000	0	500	0	80	1	1	2
Seine Net	150000	0.17	600	0.2	60	0	0.37	3

Where:
X_1 = average fish yield per year (kg);
X_2 = average fish yield per trip (kg);
X_3 = average fish yield per trip (kg);
V(A) = value function for A alternative;

Social aspect of the fishing gear performances, showed hand line was top priority (Table 3).

Table 3

Social aspects of fishing gear performances

Fishing gears	*Criteria*						*V(A)*	*Priority*
	X1	*V1(X1)*	*X2*	*V2(X2)*	*X3*	*V3(X3)*		
Pole and Line	15	1	2	0	3	0	2.5	1
Hand Line	2	0	3	1	4	1	1	2
Seine Net	4	0.18	2	0	3	0	0.37	3

Where:
X_1 = number of crew;
X_2 = technology proficiency level with score:
1 = difficult in its operation
2 = slightly difficult in its operation
3 = easy in its operation
X_3 = Respond of local fishermen with criteria: 1). Low investment cost, 2). Profitable, 3) not conflict with local culture, 4) Not conflict with regulation
Score:
1 = fishing gear fulfill 1 of 4 above criteria
2 = fishing gear fulfill 2 of 4 above criteria
3 = fishing gear fulfill 3 of 4 above criteria
4 = fishing gear fulfill all above criteria
V(A) = value function of A alternative , that sum of $V_i(X_i)$.

Economic aspect of the fishing gear performances showed that pole and line was top priority (Table 4).

Table 4

Value function of economic aspects

Fishing gears	Criteria										V(A)	Priority
	X1	V1 (X1)	X2	V2 (X2)	X3	V3 (X3)	X4	V4 (X4)	X5	V5 (X5)		
Pole and line	250	1	10	1	3	1	699	1	1.52	1	5	1
Hand line	90	0.2	8	0.5	1	0.01	47.3	0.07	1.33	0.67	1.45	2
Seine net	50	0	6	0	0.8	0	0	0	0.94	0	0.94	3

Where:

X_1 = Average gross benefit per year (Rp million);
X_2 = Average gross benefit per trip (Rp million);
X_3 = Average gross benefit per crew (Rp million);
X_4 = Benefit per year (Rp million);
X_5 = *Revenue Cost Ratio* per year (R/C);
V(A) = value function of A alternative, that sum of $V_i(X_i)$.

Based on combination of all management aspects (Table 5), showed that pole and line was more excel in technical and economic aspects whereas in biological and social aspects was most suitable the hand line. Over all management aspect, pole and line was top priority. Based on business prospective, pole and line and hand line were more feasible to develop due to profitable whereas seine net was suffering financial loss.

Table 5

Value function of combined all aspects

Fishing gears	Criteria				V(A)	Priority
	V(A)1	V(A)2	V(A)3	V(A)4		
Pole and line	3.67	2,5	1	5	12.37	1
Hand line	4.5	1	2	1.37	8.87	2
Seine net	0	0.37	0.18	0.94	1.49	3

Where:

$V(A)_1$ = biological aspect;
$V(A)_2$ = technical aspect;
$V(A)_3$ = social aspect;
$V(A)_4$ = economic aspect;
V (A) total = value function of A alternative, that sum of $V_i(X_i)$.

Discussion. Result of the study showed that pole and line fishing unit were feasible to develop. The main reason was longer fishing season compare with hand line and seine net. Pole and liner capacity range 28–35 GT and main engine size 240–450 HP, that bigger than those of hand line and seine nets, cause fishing ground more away and also even bad weather condition the fishing operations still can conducted (Mallawa & Palo 2009). Fishing ground for hand line and seine net were only around 3 to 4 mile off coast line and during bad weather condition the fishing operation cannot persist.

Based on fish catch size, hand line catch was bigger than those of pole and line and seine net. The main reason is probably due to different water depth of fishing ground. Fishing ground for hand line was around fish aggregating device and setting at around 100 m deep. While pole and line and seine net only operate in the surface water.

Fishing selectivity indicated that hand line catches bigger fish and also more uniform size compare with pole and line and seine net. The used of uniform hook size also contributed to the uniform size fish catches (Mallawa 2013, 2012). He also found that hand line fishing technology had high score in the biological aspect and also had high selectivity. Baskoro (1999) also found that hand line fishing technology had high score in the biological aspect. Rukka (2006) also stated that troll line fishing had high priority based on biological performance.

Fishing ground for seine net were around 2-3 mile off coast line with 40-50 m water depth. Whereas net mesh size at cod end ranged 1.5 to 5 cm, so the small fishes can escape through the net but the other young fish that under feasible capture size still retained. The proportion of *K. pelamis* unsuitable size retained in seine net was bigger compare with those hand line and pole and line.

Pole and line used hook number 2.5 to 4 with skipjack fish as the main target that possible cause varies in fish size and also some of them were under suitable size for responsible fishing.

Environmental friendly fishing technology criteria according to Monintja (2000) were high selectivity, that mean the fishing technology used is able to minimize non target fish species; nondestructive habitat, that can cause damage to sustainable fish production; safe for fishermen to operate the fishing technology; produce high quality fish and safe for consumer healthy; minimum impact on biodiversity; and socially accepted by local community. Arimoto (1999) stated that environmental friendly fishing technology is a fishing gear that has no negative impact on environment, not damage the water bottom (benthic disturbance), has less possible lost and low contribution on pollution.

Technical aspect showed that pole and line was the top priority. The possible reason for this due to boat size is bigger than the others two fishing gears, less fishing limitation, so the fishing season getting longer up to more than 9 months. The fishing ground was far away from fishing based.

Social aspect showed that hand line was the top priority. The driver factor because hand line had low investment and low operational cost and also highly accepted by the local community. The majority of local community had low economic capacity so in production process the fishermen will select the lowest investment cost.

Economic advantages was *K. pelamis* catching value minus all production cost for catching *K. pelamis*. The fishing ability of pole and line was bigger than the other fishing gears, and also higher *K. pelamis* production. Fish yield production is close related with fish price, as fish production is getting bigger than the return is also higher. As a result, the income of pole and line crew is bigger than hand line and seine net.

Feasibility business analysis, found Revenue Cost Ratio value 1.52 for pole and line, the R/C >1 that mean feasible to develop and benefit for business owners.

Overall aspects, pole and line fishing technology was superior in both technical and economical aspects. Pole and line fishing gear was more productive and achieved higher fish yield compare to both hand line and seine net and got more profit. Regarding the biological and social aspects hand line has get top priority due to its high selectivity and environmental friendly aspect and also for low investment requirement. The local communities have more concern in the investment require due their capital limits. Sultan (2004) found the fishing gears categorize as environmental friendly at Selayar Regency, which were drift gill net, troll line, hand line, squid angling, bottom long line, trap, shark long line and purse seine. Syamsuddin et al (2008) found that pole and line and troll line at Flores Sea and Sawu Sea categorize as environmental friendly fishing technology.

Analysis based on biological, technical, social and economic aspects of *K. pelamis* fishing units at Luwu Regency conclude that the priority for its developments were pole and line, hand line and seine net respectively.

Phenotypic diversity within fish populations has serious implications for reproductive capacity of fish stocks, and neglecting this situation could overestimate yield and catch potentials and collapse fish stocks (Akpalu & Bitew 2011). Technology/gears used in fishing may also affect marine ecology, and consequently, the carrying capacity of fish stocks. Fisheries managers account for both situations in their modeling process and in setting fishing regulations to avoid stock collapse. Fishermen who used small boat highly contributed to the fisheries sector in Indonesia. Tuna fish resources still has high potential and require management in order to maintain its sustainability (Duggan & Kochen 2016).

Local government should play an important role in maintaining fish stock around his area. Most of fish stock around the coastal area has indicated over exploited including *K. pelamis* fish. Moreover many fishing gears in field were not environmental friendly fishing gears. In order to maintain fish stock in certain area, local government should take action.

Conclusions. Performance analyses toward three fishing gears based on biological, technical, social and economic aspects were priority for developing pole and line, hand line and seine net respectively. The main priority of fishing gears for future development in Bone Bay, Luwu Regency, South Sulawesi, Indonesia, was first pole and line, second hand line and last seine net. Pole and line fishing gear recorded the best performance than others fishing gear in District Luwu. The fishing gear was also suitable to be continued and developed in the future because its profitability and short time payback period.

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